Vol. 85 No. 1, pp. 1–38 30 August 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

PHYTOPLANKTON COMPOSITION IN THE SOUTHEASTERN PACIFIC BETWEEN ECUADOR AND THE GALÁPAGOS ISLANDS (ARCHIPIÉLAGO DE COLÓN)

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The western border of South America is exposed to the northward-moving Peru Current System. This flow is directed to the northwest off the coast of Ecuador, to contribute to the south equatorial current moving westward. The Galápagos Islands are situated along the northern border of this current system, approximately 816 km beyond the coast of Ecuador. Wyrtki (1967) has described an equatorial front that commonly exists between these locations, which separates the tropical surface waters north of this front, from the cooler and more saline equatorial surface waters to the south. Wyrtki presents this front as continuing westward to and beyond the Galápagos Islands.

Phytoplankton collections in the Peru Current System have indicated predominantly a diatom flora of *Chaetoceros*, *Rhizosolenia*, *Corethron*, *Synedra*, and *Planktoniella* species (Gunter, 1936; Hendy, 1937; Krasske, 1941). Mann (1907) described diatoms he found in dredgings off the Galápagos Islands. However, his findings are limited in scope, due to his preparation methods which resulted in a high loss of the more delicate diatoms. Hendy (1937) made collections of diatoms

[1] The author thanks the Stanford Oceanographic Expedition Program for use of facilities aboard the R/V *Te Vega* during Cruise #19 supported by NSF grants GB6870 and GB6871.

off Santa Elena and Cape Blanco, located north and south of the Gulf of Guayaquil. He noted counts consisting of up to 23 diatom species at the cooler and more shallow coastal stations off Cape Blanco (St. WS 708–714). The numbers of diatom species decreased seaward with only *Rhizosolenia alata*, *R. hebetata*, and *Licmophora lyngbyei* reported at a station 78 km off the coast. The phytoplankton composition off Santa Elena (St. WS 715) contained *Chaetoceros* as the most common of six diatom species present. This station was in warmer waters directly off the coast. Hendy did not include any of the phytoflagellates in his listings. Marshall (1970) described the phytoplankton composition along a transect extending north of the Gulf of Guayaquil to the Gulf of Panama. The phytoplankters were predominantly a warm-water flora along this tract, with diatoms in greater abundance in the near-shore stations and the phytoflagellates more numerous in open waters. West of the Galápagos Islands, equatorial phytoplankton has been described by Pavillard (1935), Graham and Bronikovsky (1944), Rampi (1952), Hasle (1959, 1960a, 1960b), and Semina (1960, 1962). Desrosieres (1969) reported macrophytoplankton composition along the equatorial Pacific, sampling from the Galápagos Islands westward. He noted a definite decrease in the amount of macroplankton and nutrients along this transect.

The major purpose of this paper is to present observations on the phytoplankton composition east of the Galápagos Islands to Ecuador, and to note the phytoplankton in the waters within the channels of this island complex.

Methods

Phytoplankton and hydrography data were obtained during Stanford Oceanographic Expedition #19 aboard the *Te Vega* in August 1968. Nansen water bottles were used to obtain water samples at the surface, 10, 30, 75, 100, 150, 200, and 300 meters at each of the open-water stations. In addition, surface water bucket samples were taken between the various islands, while aboard a ketch operated by Mr. Karl Angermeyer. In each case, a 500 ml water sample was preserved immediately with neutralized formalin for phytoplankton analysis. After a 3-week settling period, a 30–40 ml concentrate was obtained by siphoning. The concentrated samples were transferred to 50 ml settling cylinders for examination with a Zeiss inverted microscope (12.5 × ocular and 40 × objective, NA 0.65).

Gratitude is expressed to Mr. Thomas Malone for chemical analysis of water samples made aboard the *Te Vega*, and to Dr. Andrew McIntyre and Mr. J. A. Kostecki of the Lamont Geophysical Laboratory for preparation of EM grids and subsequent use of an electron microscope used in the identification of coccolithophores. Appreciation is also extended to Mr. Roger Perry and the staff of the Darwin Research Station for use of their facilities in Santa Cruz, Galápagos.

Results and Discussion

Open-Water Stations: Five stations were located between Ecuador and the Galápagos Islands (Fig. 1). In contrast to hydro-stations located within the waterways of the island complex, these will be referred to as open-water stations. The greatest numbers and species diversity of phytoplankters occurred at station 91, located approximately 150 km west of Santa Elena, Ecuador. This station was located farther south (2° 29′ S lat.), had the coldest surface temperature (19.35°C), and highest surface salinity (34.85‰), than the other three stations. A corresponding decrease in surface salinity and oxygen content was also recorded north of station 91. An apparent oceanic front was crossed proceeding northwest to stations 141 and 137, where surface temperatures were 24.50°C (1° 33″ S lat.) and 24.59°C (0°00′ lat.), respectively. The warmer surface waters at these stations overlaid a colder and more saline water mass. Temperature and salinity values varied slightly over the first 10 m of depth. However, the temperature drop between 10 and 30 m was over 5°C at each of these two stations (Table 1). Salinity values also decreased sharply with maximum salinity reached at approximately 75 m for both stations. A slightly lower thermocline appeared at stations 91 and 95 between 30 and 75 m. The oxygen values for

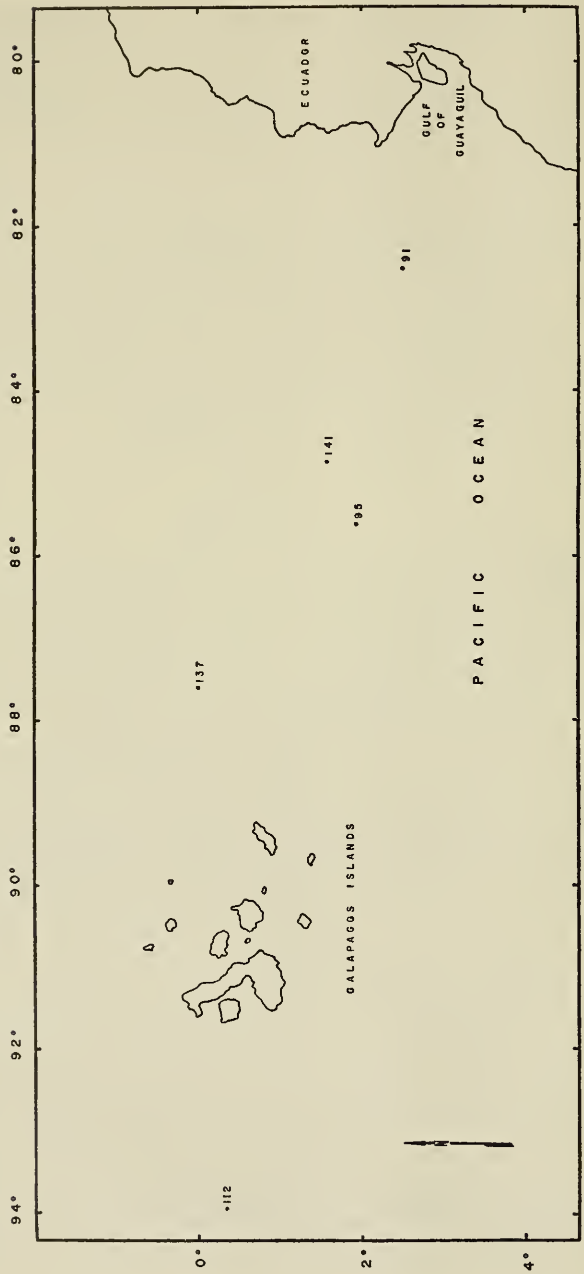

FIG. 1. The location of hydrostations east and west of the Galápagos Islands.

TABLE 1. Data obtained at open-water stations between Ecuador and the Galápagos Islands.

Depth m	T °C	S ‰	O_2 ml/l	PO_4-P µgA/l	NO_3-N µgA/l
I. Station 91. Location: 02° 29′ S, 82° 30′ W. Date: 8 August 1968					
0	19.35	34.85	5.30	1.0	10.8
10	19.36	34.85	5.23	0.8	—
30	19.30	34.89	5.14	0.8	18.6
75	16.19	35.04	2.31	1.4	13.4
100	15.38	35.00	1.99	1.5	40.0
150	14.81	34.99	1.76	1.6	—
200	14.18	34.97	1.65	1.6	26.5
300	13.30	34.94	0.31	2.3	45.5
II. Station 95. Location: 01° 56′ S, 85° 37′ W. Date: 11 August 1968					
0	21.18	34.80	4.85	0.7	0.0
10	21.12	34.80	5.05	0.8	0.0
30	21.12	34.80	4.96	0.8	8.5
75	15.09	35.06	2.11	1.5	25.1
100	14.58	35.01	1.93	1.6	26.0
150	14.27	34.96	1.45	1.7	12.0
200	13.82	34.97	1.6	1.4	27.4
300	12.84	34.92	0.3	2.4	40.2
III. Station 99.* Location: 01° 20′ S, 88° 56′ W. Date: 12 August 1968					
0	22.16	34.38	4.99	1.5	2.5
10	22.12	34.38	5.10	–	37.9
30	21.72	34.42	4.85	1.7	62.7
75	16.54	35.10	2.82	6.8	20.1
100	—	—	–	–	—
150	14.27	35.01	2.28	4.6	29.4
200	13.76	34.97	2.25	–	25.5
300	12.84	34.93	0.47	6.1	43.0
IV. Station 137. Location: 00° 00′, 87° 37′ W. Date: 26 August 1968					
0	24.59	33.96	4.68		
10	24.61	33.96	4.91		
30	19.95	—	2.99		
75	15.64	35.13	2.71		
100	14.78	35.09	3.08		
150	14.29	35.07	2.06		
200	13.80	35.02	0.93		
300	10.95	34.87	0.39		

* Station 99 also listed as inter-island station 1.

TABLE 1. Continued.

Depth m	T °C	S ‰	O_2 ml/l	PO_4-P μgA/l	NO_3-N μgA/l
V. Station 141. Location: 01° 33′ S, 84° 52′ W. Date: 27 August 1968					
0	24.50	33.91	4.65		
10	24.48	33.91	5.20		
30	19.32	34.99	4.91		
75	16.27	35.13	2.36		
100	15.40	35.07	2.25		
150	16.64	35.01	1.82		
200	14.15	34.99	1.61		
300	11.25	34.83	0.10		

the upper 30 m at the open-water stations ranged from 2.99 ml/l at 30 m, station 137, to 5.30 ml/l from the surface at station 91. Values recorded below these depths decreased from 2.71 ml/l at 75 m (station 137) to 0.3 ml/l at 300 m (stations 91 and 95). The phosphate concentrations at stations 91 and 95 ranged in the upper 30 m between 0.7 and 1.0 μgA/l, with nitrates ranging from 0.0 to 8.5 μgA/l at station 95, and 10.8 to 18.6 μgA/l at station 91. Nutrient analysis at station 99, located 67 km east of the Galápagos Islands, showed higher values for both phosphate and nitrate concentrations. Over the upper 30 m, nitrates increased from 2.5 to 62.7 μgA/l with depth, with phosphates at 1.5 to 1.7 μgA/l.

Thirty-nine phytoplankters were identified at station 91 (0–300 m). The diatoms predominated in numbers, with *Chaetoceros decipiens*, *Coscinodiscus* spp., *Guinardia flaccida*, and *Rhizosolenia* spp. representing the majority of species. There were 29 diatom, nine pyrrhophycean, and one silicoflagellate species observed at this station. The numbers of total phytoplankton decreased, with fewer species of diatoms observed, at stations west and north of 91 (Table 4). This decline in numbers continued westward to the surface samples taken 67 km east of San Cristobal (station 99). In all of these later stations, both diatoms and dinoflagellates were represented, but there were no large numbers of any one species.

A wide vertical distribution of phytoplankters occurred only at station 91. Generally, the diatoms were common at all the

TABLE 2. Location of inter-island stations with surface water temperatures and dates of sampling.

Station Number	Location	°C	Date
1	1° 20′ S, 88° 56′ W	22.2	12 August 1968
2	1° 06′ S, 89° 20′ W	23.2	12 August 1968
3	Wreck Bay	22.4	24 August 1968
4	Canal de Santa Fe	22.4	16 August 1968
5	Canal de Santa Cruz	22.6	16 August 1968
6	Barrington Cove	23.4	16 August 1968
7	Academy Bay	24.6	16 August 1968
8	Canal de Isabella	22.4	18 August 1968
9	Canal de Isabella	22.5	19 August 1968
10	Canal de Pinzon	22.0	19 August 1968
11	Canal de San Salvador	23.0	19 August 1968
12	Daphne-Baltra Canal	22.2	22 August 1968
13	Canal de Itabaca	23.0	22 August 1968
14	Canal de Itabaca	23.2	22 August 1968
15	Plaza-Santa Cruz Canal	22.2	23 August 1968
16	Sullivan Bay	22.0	19 August 1968
17	Sullivan Bay	22.2	20 August 1968
18	Canal de Marchena	22.2	20 August 1968
19	Canal de Pinta	23.2	20 August 1968
20	Canal de Pinta	23.8	21 August 1968
21	Santa Maria-Isabella Canal	22.6	19 August 1968
22	Tagus Cove	21.7	17 August 1968
23	Elizabeth Bay	22.2	22 August 1968

depths sampled to 300 m. However, low counts were common in surface samples at each of the four stations. Concentrations were most abundant in depths to 100 m, then the numbers declined rapidly. The average oxygen values at the four open-water stations were 4.87, 2.56, 1.45, 0.27 ml/l respectively for the surface and approximate depths of 100, 200, and 300 m. Although several species were found restricted to depths above

TABLE 3. Data obtained from surface samples taken at stations 22 and 112.

Station Number	Location	Date	T °C	S ‰	O_2 ml/l	PO_4-P µgA/l	NO_3-N µgA/l
22	Tagus Cove	18-8-68	21.70	34.95	5.57	0.3	0.3
112	0°17′N, 93°59′W	16-8-68	21.86	34.58	4.19	1.0	1.2

Table 4.

STATION	#91								#95							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
DIATOMS																
Asteromphalus hepaticus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bacteriastrum delicatulum	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
Chaetoceros sp.	–	–	–	–	–	10	–	2	–	–	–	–	–	–	–	–
Chaetoceros danicus	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros decipiens	–	18	16	–	22	88	48	8	–	6	–	–	–	–	–	–
Chaetoceros didymus	–	–	–	8	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros horridum	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros peruvianus	3	–	–	–	–	–	–	–	2	–	4	–	–	–	–	–
Chaetoceros pseudocurvisetus	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–
Coscinodiscus sp.	–	126	–	10	12	–	–	2	–	–	–	–	–	–	–	–
Coscinodiscus excentricus	–	20	–	56	8	–	–	–	–	–	–	–	–	–	–	–
Coscinodiscus nitidus	–	–	–	–	–	–	–	–	–	–	–	4	2	–	2	–
Guanardia flaccida	–	154	–	16	–	–	–	–	–	–	–	–	–	–	–	–
Navicula sp.	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia longissima	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia pacifica	–	–	–	–	–	–	12	–	–	–	–	20	6	–	–	–
Nitzschia pungens atlantica	–	–	–	–	–	4	14	–	–	–	–	–	–	–	–	–
Planktoniella sol	–	2	2	8	–	4	2	–	12	16	3	–	–	–	–	–
Pleurosigma sp.	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–
Pseudoeunotia doliolus	–	–	–	–	32	2	–	–	–	–	–	8	4	–	–	–

TABLE 4. Continued.

STATION	#91								#95							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
DIATOMS																
Rhizosolenia alata	6	68	42	50	20	8	8	4	–	4	4	2	2	6	–	–
Rhizosolenia calcar-avis	–	–	–	4	–	2	–	4	–	–	–	–	–	–	–	–
Rhizosolenia robusta	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
Rhizosolenia setigera	–	–	–	–	8	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia stolterfothii	–	4	–	–	4	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia styliformis	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–
Stephanopyxis palmeriana	–	–	–	–	–	6	2	–	–	–	–	4	–	–	–	–
Stephanopyxis turris	–	–	–	8	2	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix curata	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix frauenfeldii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix mediterranea	–	10	–	4	–	–	–	–	–	–	–	–	–	–	–	–
Thalassionema delicatula	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
Thalassionema nitzschioides	–	–	–	72	24	–	12	–	–	–	–	–	–	–	–	–
Tropidoneis sp.	–	–	–	–	–	–	2	–	–	6	–	–	–	–	–	–
Total Diatoms	9	424	60	236	138	124	114	24	14	32	11	38	14	6	2	0
PYRRHOPHYTA																
Amphisolenia globifera	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium breve	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium furca	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 4. Continued.

STATION	#91								#95							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
PYRRHOPHYTA																
Ceratium fusus	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Ceratium pentagonium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium tripos	–	2	–	–	–	–	–	–	–	12	–	–	–	–	–	–
Exuviella sp.	–	2	–	–	–	8	–	–	–	12	–	12	–	–	–	–
Gymnodinium sp.	–	–	–	–	–	–	2	–	–	12	–	–	–	–	–	–
Oxytoxum caudatum	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–
Oxytoxum scolopax	–	–	–	4	–	–	–	–	–	–	–	–	–	4	–	–
Peridinium spp.	–	6	–	–	–	–	–	–	–	–	–	–	2	–	–	–
Phalacroma mucronatum	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–
Podolampas palmipes	–	–	–	–	6	–	–	–	–	–	–	–	6	–	–	–
Prorocentrum sp.	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified flagellates	–	8	–	8	–	–	–	–	–	–	–	–	–	–	–	–
Total Pyrrhophyta	0	18	0	14	10	10	2	0	0	38	0	12	8	4	0	0

Table 4. Continued.

STATION	#91								#95							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
SILICOFLAGELLATES																
Dictyocha deflandrei	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–
Dictyocha fibula	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Distephanus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Distephanus speculum	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Total Silicoflagellates	0	0	0	0	2	0	0	0	0	4	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	9	442	60	25	150	134	116	24	14	74	11	50	22	10	2	0

Table 4. Continued.

STATION	#137								#141							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
DIATOMS																
Asteromphalus hepaticus	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–
Bacteriastrum delicatulum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros danicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros decipiens	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–
Chaetoceros didymus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros horridum	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros peruvianus	–	12	–	–	–	–	–	2	–	–	–	–	–	–	–	–
Chaetoceros pseudocurvisetus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coscinodiscus sp.	–	–	–	–	–	–	–	–	–	2	–	2	6	–	–	–
Coscinodiscus excentricus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coscinodiscus nitidus	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guanardia flaccida	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Navicula sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia longissima	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia pacifica	–	12	–	12	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia pungens atlantica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Planktoniella sol	–	4	–	–	–	–	–	4	–	2	–	–	4	2	–	–
Pleurosigma sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 4. Continued.

STATION	#137								#141							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
DIATOMS																
Pseudoeunotia doliolus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia alata	–	6	–	–	–	–	–	–	–	4	–	–	2	–	–	–
Rhizosolenia calcar-avis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia robusta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia setigera	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia stolterfothii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia styliformis	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stephanopyxis palmeriana	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stephanopyxis turris	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix curata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix frauenfeldii	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix mediterranea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassionema delicatula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassionema nitzschioides	–	16	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tropidoneis sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total Diatoms	0	74	0	12	0	0	0	6	0	20	0	2	12	4	2	0
PYRRHOPHYTA																
Amphisolenia globifera	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–
Ceratium breve	–	2	–	–	–	–	2	–	–	–	–	–	2	–	–	–

TABLE 4. Continued.

STATION	#137								#141							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
PYRRHOPHYTA																
Ceratium furca	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–
Ceratium fusus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium pentagonium	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Ceratium tripos	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Exuviella sp.	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gymnodinium sp.	–	6	–	–	–	–	–	–	4	–	–	–	–	–	–	–
Oxytoxum caudatum	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–
Oxytoxum scolopax	–	12	–	–	–	–	–	–	10	–	–	–	–	–	–	–
Peridinium spp.	–	8	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Phalacroma mucronatum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Podolampas palmipes	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Prorocentrum sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified flagellates	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–
Total Pyrrhophyta	0	32	2	0	0	0	2	0	30	0	0	4	4	0	0	0

TABLE 4. Continued.

STATION	#137								#141							
DEPTH (M)	0	10	30	75	100	150	200	300	0	10	30	75	100	150	200	300
SILICOFLAGELLATES																
Dictyocha deflandrei	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichtyocha fibula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Distephanus sp.	–	–	–	–	–	0	2	–	–	–	2	–	–	–	–	–
Distephanus speculum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total Silicoflagellates	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
TOTAL PHYTOPLANKTON	0	106	2	12	0	0	4	6	30	20	2	6	16	4	2	0

or below 100 m, the limited number of vertical samples prevent general statements about the species spatial distribution. *Rhizosolenia alata* and *Planktoniella sol*, and *Oxytoxum scolopax* were found at all four open-water stations. Silicoflagellates were noted in low concentrations at each station, with their presence rare, but more common at the lower depths. There were only slight changes in the phytoflagellates observed at these stations, with the largest numbers of total cells found at station 95.

The surface phosphate and nitrate concentrations at these stations are below values reported by Desrosieres (1969) directly west of the Galápagos. Sampling along the equator from east to west, he noted a decrease in phosphate and nitrates content accompanied by a temperature rise and decline in the standing crop. High nutrient values were reported in the Peru Current and waters east and west of the Galápagos Islands by Forsbergh and Joseph (1964). Holmes et al. (1957) further reviewed the primary production of the tropical eastern Pacific and showed chlorophyl data and zooplankton volumes support the presence of high productivity off northwest South America to and west of the Galápagos Islands.

Station #112. (0° 17′ N lat. 93° 59′ W long.): Located 225 km west of Fernandina Island, only a surface sample was taken at this most western station of the present collections. The phytoplankton consisted mainly of the diatoms *Nitzschia delicatissima, N. pacifica, Planktoniella sol, Rhizosolenia alata,* and *Thalassionema delicatula.* The common phytoflagellates were *Ceratium paradoxides, Oxytoxum scolopax, Peridinium* sp., and the lone silicoflagellate was *Mesocena* sp. A variety of copepods, nauplii, and tintinnids were also abundant. *R. alata* and *R. bergonii* were both common. *R. bergonii* was also prominent within the waters of the island complex, but was not found east of the Galápagos Islands.

Although limited to a surface sample at station 112, the total numbers of species and total phytoplankton, were greater here than any of the other surface stations located east of the Galápagos Islands. This sample also included large numbers of coccolithophores. The cold-water form of *Emiliania huxleyi* (*Coccolithus huxleyi*) and *Gephyrocapsa oceanica* were most common. The other coccolithophores at this station were *Cyclococcolithus leptoporus*, *Umbellosphaera irregularis*, and *Discosphaera tubifera*.

Nitrate and phosphate concentrations of 1.0 and 1.2 μgA/l at this station were higher than surface values obtained at open-water stations east of the Galápagos Islands. However, these concentrations were below those obtained by Desrosieres (1969), yet support his conclusions of enriched waters and high phytoplankton density immediately west of the Galápagos Islands. Unfortunately, nutrient values were not obtained at other depths in the photic zone at station 112. Desrosieres noted at his station (#3) closest to the Galápagos, that the dominant species were *Rhizosolenia bergonii*, *Planktoniella sol*, *Pseudoeunotia doliolus*, *Coscinodiscus* sp., *Ceratium agaricum* and *C. furca*. These species, with the exception of *P. doliolus* which was found at stations 91 and 95 and *C. agaricum*, which was not observed, correspond closely to the most abundant species found at station 112. Pavillard (1935), who had his station No. 2 located more to the southwest (2° S long. 94° W), observed the diatoms *Coscinodiscus* spp., *P. sol*, *R. bergonii*, *Asteromphalus elegans*, *A. heptactis*, and 16 phytoflagellate species. An increase in the ratio of the phytoflagellates to the diatoms apparently is characteristic westward in the open ocean along the equator (Hasle 1959, Semina 1962).

Inter-island stations: Surface water samples were taken at 23 stations in the waterways and bays among the islands and are referred to as inter-island stations (Fig. 2). Station locations and surface water temperatures are given in Table 2. Temperatures was taken at mid-day, and ranged from 21.7°C in Tagus Cove, on the west coast of Isabela, to 24.6°C in Academy Bay at Santa Cruz. The currents in the open waters were constantly strong, flowing northwest at 1–2¾ knots.

The lowest concentrations of phytoplankters occurred in the waters bordering the southern fringe of the island complex (stations 1–8, 21). Total counts for these stations ranged from 24 to 326 cells per liter (Table 5). This was the only area where *Biddulphia laevis*, *Licmophora abbreviata* and *Melosira jurgesii* were common. Other diatoms and the pyrrhophyta

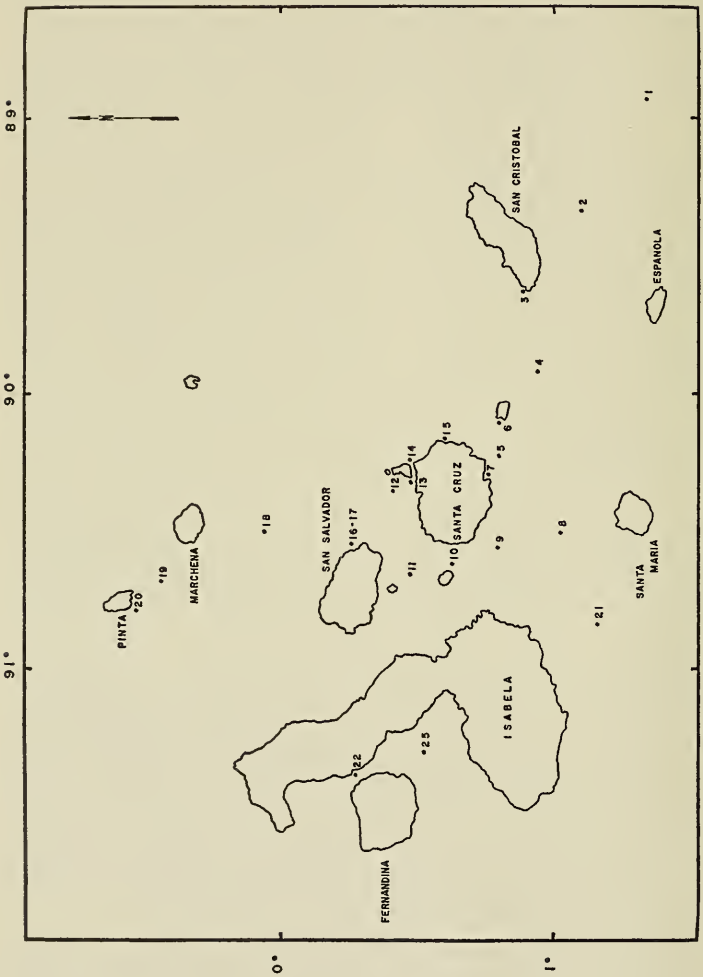

Fig. 2. The Galápagos Islands with the location of hydrostations, numbers 1 through 23.

TABLE 5. Phytoplankton composition from surface samples at 23 stations between the Galápagos Islands and at Station 112. Values refer to number of cells per liter.

	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
DIATOMS												
Asteromphalus heptactis	–	–	–	–	–	–	–	–	–	–	–	–
Asterolampra marylandica	–	–	–	–	–	–	–	–	–	–	–	–
Biddulphia sp.	–	–	–	–	–	4	–	–	–	–	–	–
Biddulphia laevis	–	–	–	8	12	–	44	–	–	–	–	–
Cerataulina bergonii	–	–	–	–	–	–	–	–	–	–	–	96
Chaetoceros atlanticus neopolitana	–	–	–	–	–	–	–	–	–	–	48	–
Chaetoceros coarctatus	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros curvisetus	–	–	–	–	–	–	–	–	–	–	–	3200
Chaetoceros danicus	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros decipiens	10	8	–	–	–	–	–	–	–	–	–	64
Chaetoceros didymus	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros peruvianus	6	4	–	2	–	–	–	–	2	4	15	12
Chaetoceros sp.	–	–	–	–	–	–	–	–	–	–	–	–
Coscinodiscus sp.	4	2	2	–	–	–	–	–	–	–	–	–
Coscinodiscus excentricus	–	–	–	–	–	–	–	–	–	–	–	–
Coscinodiscus lineatus	–	–	–	–	–	–	–	–	6	–	–	–
Corethron sp.	–	–	–	–	–	–	–	–	–	–	–	–
Eucampia cornuta	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 5. Continued.

	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
DIATOMS												
Grammatophora marina	–	–	–	–	–	–	2	–	–	–	–	–
Hemiaulus hauckii	–	–	–	–	–	–	–	–	–	–	–	–
Licmophora abbreviata	–	–	–	12	16	4	74	–	4	–	–	–
Licmophora ehrenbergin	–	–	–	–	–	–	–	–	–	–	–	–
Melosira jurgensii	–	–	–	10	4	8	76	–	–	–	–	–
Navicula sp.	–	–	–	–	–	1	–	–	–	–	–	–
Nitzschia bicapita	–	–	–	–	–	6	6	–	–	–	–	–
Nitzschia delicatissima	–	–	–	–	–	8	4	–	192	120	18	4760
Nitzschia longissima	–	–	–	–	–	8	8	–	–	–	–	–
Nitzschia kolacyekii	–	–	–	–	–	–	8	–	–	–	–	–
Nitzschia pacifica	–	–	–	–	–	–	12	–	–	–	28	–
Nitzschia pungens atlantica	–	–	–	–	–	–	–	–	–	–	–	3240
Plagiogramma vanheurckii	–	–	–	–	–	24	–	–	–	–	–	–
Planktoniella sol	4	4	–	8	4	–	2	4	–	6	10	4
Pleurosigma sp.	–	–	–	–	–	4	–	–	–	–	–	2
Rhizosolenia alata	4	2	4	8	2	–	–	2	–	–	64	12
Rhizosolenia bergonii	–	–	–	–	–	–	–	–	26	14	28	–
Rhizosolenia calcar-avis	–	–	–	–	–	–	–	–	–	–	–	6
Rhizosolenia hebetata semispina	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 5. Continued.

	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
DIATOMS												
Rhizosolenia imbricata	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia stolterfothii	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia styliformis	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix frauenfeldii	–	–	–	–	–	–	16	12	14	12	48	28
Thalassiothrix mediterranea	–	–	–	–	–	–	–	–	–	–	–	–
Thalassionema elegans	–	–	6	–	–	–	–	–	–	–	–	68
Thalassionema delicatula	–	–	–	10	–	–	–	–	–	–	68	18
Thalassionema nitzschioides	6	–	–	–	–	–	8	–	–	–	–	42
Thalassiosira oestruppii	–	–	–	–	–	–	–	–	40	8	–	–
Tropidoneis sp.	–	–	–	2	–	–	34	8	10	12	18	8
Unidentified diatoms	–	–	–	8	–	–						
Total Diatoms	34	20	12	68	38	67	294	26	244	176	345	11560
PYRRHOPHYTA												
Amphisolenia sp.	–	–	–	–	–	2	–	–	–	–	–	–
Ceratium declinatum	–	–	–	2	–	–	–	–	–	–	–	–
Ceratium furca	–	–	–	–	–	–	–	–	8	–	–	–
Ceratium massiliense	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 5. Continued.

	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
PYRRHOPHYTA												
Ceratium paradoxides	–	–	–	2	–	–	–	–	–	–	–	–
Ceratium trichoceros	–	–	–	–	–	–	–	–	2	–	–	–
Ceratium tripos	2	–	–	–	–	–	–	–	–	–	–	–
Danasphaera indica	–	–	–	2	–	–	–	–	–	–	–	–
Dinophysis acuminata	–	–	–	–	–	–	–	–	–	–	–	–
Exuviella sp.	–	–	–	–	–	–	–	–	–	–	–	–
Glenodinium dankum	–	–	–	–	–	–	–	–	–	–	–	–
Gonyaulax kofoidi	–	–	–	–	–	–	–	–	2	–	–	–
Gymnodinium sp.	–	–	–	–	–	–	–	–	–	–	–	2
Gymnodinium oceanicum	–	–	2	–	–	–	–	–	–	–	–	–
Gyrodinium sp.	–	–	–	–	–	–	–	–	–	–	–	–
Murrayella spinosa	–	–	–	–	–	–	–	–	–	–	–	–
Oxytoxum scolopax	–	–	2	2	–	–	–	–	6	–	–	4
Peridinium spp.	–	–	–	–	–	6	–	–	12	–	2	–
Peridinium globulus	–	–	–	–	–	–	–	–	–	–	–	–
Peridinium solidcorne	–	–	–	–	–	–	–	–	–	–	–	4
Phalacroma sp.	–	–	–	–	–	–	–	–	–	–	–	–
Phalacroma mucronatum	–	–	–	–	–	–	–	–	–	–	–	–

Table 5. Continued.

	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
PYRRHOPHYTA												
Podolampas bipes	–	–	–	–	–	–	–	–	–	–	2	–
Podolampas palmipes	–	–	–	2	–	–	–	–	–	–	–	–
Podolampas sp.	–	–	4	–	–	–	–	–	–	–	–	4
Prorocentrum sp.	–	–	–	–	–	–						
Total Pyrrhophyta	2	0	8	10	0	8	0	0	30	0	4	12
SILICOFLAGELLATES												
Dictyocha fibula	2	4	4	2	–	–	–	–	–	–	2	–
Distephanus speculum	–	–	–	–	–	–	–	–	–	–	–	–
Distephanus speculum octonarius	–	–	4	12	–	–	–	–	–	–	–	–
Mesocena sp.	–	–	–	–	–	2	–	–	–	–	–	–
Mesocena polymorpha biseptenaria	–	–	–	–	–	–	–	–	2	–	4	–
Total Silicoflagellates	4	4	8	14	0	2	0	0	2	0	6	0
TOTAL PHYTOPLANKTON	40	24	28	92	38	77	294	26	326	176	355	11572

TABLE 5. Continued.

	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	112
DIATOMS												
Asteromphalus heptactis	–	–	–	–	–	–	–	–	4	–	–	–
Asterolampra marylandica	–	–	–	–	–	–	–	–	–	12	–	–
Biddulphia sp.	–	–	–	–	–	–	–	–	–	–	–	–
Biddulphia laevis	–	–	–	–	–	–	–	–	–	–	–	–
Cerataulina bergonii	702	120	52	148	–	24	8	12	–	–	–	–
Chaetoceros atlanticus neopolitana	–	32	–	–	–	–	–	–	–	–	–	–
Chaetoceros coarctatus	–	–	6	–	–	–	–	–	–	–	–	–
Chaetoceros curvisetus	1594	–	6	2160	–	24	4	–	–	–	–	–
Chaetoceros danicus	780	–	–	–	–	–	–	–	–	–	–	–
Chaetoceros decipiens	40	–	420	180	358	4	22	10	16	–	–	–
Cheaetoceros didymus	–	–	–	–	8	–	–	–	–	–	–	–
Chaetoceros peruvianus	–	–	–	–	4	2	4	–	8	16	–	–
Chaetoceros sp.	–	24	24	–	–	–	–	–	–	–	–	–
Coscinodiscus sp.	56	–	–	–	–	–	–	–	2	8	2	–
Coscinodiscus excentricus	4	–	–	–	–	–	–	–	–	–	2	2
Coscinodiscus lineatus	–	–	–	–	4	–	–	–	–	–	–	–
Corethron sp.	–	–	–	–	2	–	–	–	–	–	–	–
Eucampia cornuta	–	–	–	–	–	–	–	–	–	–	–	–
Grammatophora marina	4	–	–	–	–	–	24	36	–	–	–	–

TABLE 5. Continued.

	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	112
DIATOMS												
Hemiaulus hauckii	8	–	–	–	4	–	–	–	–	–	–	–
Licmophora abbreviata	–	–	–	–	–	–	–	–	–	–	–	–
Licmophora ehrenbergin	–	–	–	–	2	–	–	–	–	–	–	–
Melosira jurgensii	–	4	–	–	–	–	–	–	–	–	–	–
Navicula sp.	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia bicapita	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia delicatissima	–	–	6	–	–	–	–	–	–	–	–	–
Nitzschia longissima	2620	5280	120	9640	646	92	840	1280	120	588	22640	154
Nitzschia kolacyekii	–	–	–	–	2	–	–	–	–	–	–	–
Nitzschia pacifica	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia pungens atlantica	864	–	20	5240	244	32	46	58	–	–	–	32
Plagiogramma vanheurckii	–	–	–	–	–	–	–	–	–	–	–	–
Planktoniella sol	–	–	–	–	–	–	–	–	–	–	–	–
Pleurosigma sp.	6	4	16	10	6	–	4	–	8	–	4	20
Rhizosolenia alata	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia bergonii	8	10	28	44	40	14	26	54	16	8	–	28
Rhizosolenia calcar-avis	2	–	2	8	62	8	–	–	4	–	–	20
Rhizosolenia hebetata semispina	2	–	12	10	–	8	–	–	–	–	–	–
Rhizosolenia imbricata	–	–	–	–	52	–	–	–	–	–	–	–

TABLE 5. Continued.

	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	112
DIATOMS												
Rhizosolenia stolterfothii	–	–	–	–	10	–	–	–	–	–	–	–
Rhizosolenia styliformis	–	–	–	–	32	–	–	–	–	–	–	–
Thalassiothrix frauenfeldii	–	–	–	–	8	–	–	–	–	–	–	–
Thalassiothrix mediterranea	30	14	192	12	40	84	–	12	–	16	–	–
Thalassionema elegans	–	–	–	–	12	–	–	–	–	–	–	–
Thalassionema delicatula	–	–	–	–	–	–	–	–	–	–	–	–
Thalassionema nitzschioides	–	–	64	32	144	54	46	122	8	–	–	20
Thalassiosira oestruppii	–	–	80	48	46	24	–	–	–	–	–	–
Tropidoneis sp.	–	–	28	52	4	50	–	–	–	396	10380	–
Unidentified diatoms	50	–	56	48	–	64	18	24	14	6	40	8
Total Diatoms	6818	5484	1130	17638	1730	484	1042	1608	200	1050	33044	284
PYRRHOPHYTA												
Amphisolenia sp.	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium declinatum	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium furca	–	16	–	–	–	–	–	–	2	–	180	–
Ceratium massiliense	–	–	–	–	–	–	2	2	–	–	–	6
Ceratium paradoxides	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 5. Continued.

	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	112
PYRRHOPHYTA												
Ceratium trichoceros	–	–	–	–	–	–	–	–	–	–	–	–
Ceratium tripos	–	–	–	–	–	2	–	–	4	–	–	–
Danasphaera indica	–	–	–	–	–	–	–	–	–	–	–	–
Dinophysis acuminata	–	–	–	16	2	–	–	–	–	2	56	–
Exuviella sp.	–	8	2	–	–	–	–	–	–	–	–	–
Glenodinium dankum	78	–	–	–	–	–	–	–	–	–	–	–
Gonyaulax kofoidi	–	–	–	–	–	–	–	–	–	20	760	–
Gymnodinium sp.	–	–	–	12	4	–	–	–	–	–	–	–
Gymnodinium oceanicum	212	–	–	–	–	–	–	–	–	28	1740	–
Gyrodinium sp.	4	–	–	–	–	–	–	–	–	8	–	–
Murrayella spinosa	–	–	–	–	–	–	–	–	–	16	–	–
Oxytoxum scolopax	–	–	–	–	–	–	–	–	6	2	40	2
Peridinium spp.	12	32	–	28	4	–	–	–	4	8	4	4
Peridinium globulus	–	–	–	–	–	–	–	–	–	–	5220	–
Peridinium solidcorne	–	–	4	–	–	–	–	–	–	–	2	–
Phalacroma sp.	–	–	–	–	–	–	–	2	–	–	–	–
Phalacroma mucronatum	–	–	–	–	–	–	–	–	–	2	–	–
Podolampas bipes	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 5. Continued.

	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	112
PYRRHOPHYTA												
Podolampas palmipes	–	–	–	–	–	–	–	–	2	4	–	–
Podolampas sp.	–	–	–	–	–	–	–	–	–	10	–	–
Prorocentrum sp.	–	–	–	2	–	–	–	–	–	100	–	–
Total Pyrrhophyta	306	56	6	58	10	2	2	4	18	200	8002	12
SILICOFLAGELLATES												
Dictyocha fibula	–	–	2	6	2	–	–	–	4	–	20	–
Distephanus speculum	–	–	2	–	–	–	–	–	–	–	–	–
Distephanus speculum octonarius	–	–	–	–	–	–	–	–	–	2	–	–
Mesocena sp.	–	–	2	44	–	6	–	6	8	–	–	8
Mesocena polymorpha biseptenaria	–	–	–	–	–							
Total Silicoflagellates	0	0	6	50	2	6	0	6	12	2	20	8
TOTAL PHYTOPLANKTON	7124	5540	1142	17746	1742	492	1044	1618	230	1252	41066	304

were in low numbers. However, in contrast to their scarcity in the open-water stations, the silicoflagellates (*Dictyocha fibula* and *Distephanus speculum octonarius*) were found at five of the nine inter-island stations. There were greater numbers of phytoplankters at the more northern stations (Nos. 18–20), where totals ranged from 492 to 1,618 cells per liter. This increase was augmented primarily by the diatoms which were dominated by *N. delicatissima.* The numbers of pyrrhophyceans and silicoflagellates were low. The pyrrhophyceans were numerous in the Canal de Itabaca and Sullivans Bay (stations 13 and 16). In the former, *Gymnodinium oceanicum* totaled 212 cells/l and *Glenodinium dankum* 78 cells/l. Total phytoplankton counts reached 17,746 cells/l in Sullivans Bays with *Chaetoceros curvisetus, N. delicatissima,* and *N. pacifica* the most numerous species. The largest concentration of silicoflagellates was also found at this station. Six *D. fibula* and 44 *Mesocena* sp. were observed. The four pyrrhophyceans at this station were *Dinophysis acuminata, Gymnodinium* sp., *Peridinium* sp., and *Prorocentrum* sp. The greatest diversity of pyrrhophyceans occurred in Tagus Cove (station 22) where 11 species were noted, but not in large numbers. The diatoms occurred in highest numbers at this station, with the silicoflagellates represented by only *Distephanus speculum.* The largest concentration of phytoplankton at any of the stations was at Elizabeth Bay (station 23). Cell counts reached 41,066 cells per liter, of which 80% were diatoms. The most numerous diatoms were *N. delicatissima* and *T. oestruppii,* having counts of 22,640 and 10,380 cells/l respectively. The most numerous pyrrhophyceans were *Gymnodinium oceanicum* and *Peridinium globulus.*

The most common of the 47 diatom species noted in the inter-island waters were *Cerataulina bergonii, Chaetoceros decipiens, Chaetoceros peruvianus, N. delicatissima, N. pacifica, P. sol, R. alata, R. bergonii, Thalassiothrix frauenfeldii, Thalassionema delicatula, T. nitzschioides, T. oestruppii,* and *Tropidoneis* sp. There were 24 diatoms limited to the inter-island waterways and bays, and 21 diatoms observed at both the inter-island and open-sea stations (Tables 6–8). This latter group was mainly composed of the genera *Chaetoceros, Cos-*

TABLE 6. Phytoplankton observed at only inter-island stations.

Diatoms	Pyrrhophyceans	Coccolithophorids	Silicoflagellates
Asterolampra marylandica	Amphisolenia sp.	Gephyrocapsa ericsonii	Distephanus speculum
Biddulphia sp.	Ceratium declinatum		Distephanus speculum octonarius
Biddulphia laevis	Ceratium massiliense		Mesocena sp.
Cerataulina bergonii	Ceratium paradoxides		Mesocena polymorpha biseptenaria
Chaetoceros atlantica neopolitana	Ceratium trichoceros		
Chaetoceros coarctatus	Danasphaera indica		
Chaetoceros curvisetus	Dinophysis acuminata		
Coscinodiscus lineatus	Glenodinium dankum		
Corethron sp.	Gonyaulax kofoidi		
Eucampia cornuta	Gymnodinium oceanicum		
Grammatophora marina	Gyrodinium sp.		
Hemiaulus hauckii	Murrayella spinosa		
Licomophora abbreviata	Peridinium globulus		
Licomophora ehrenbergin	Peridinium solidcorne		
Melosira jurgensii	Phalacroma sp.		
Nitzschia bicapita	Podolampas bipes		
Nitzschia delicatissima	Podolampas sp.		
Nitzschia kolacyekii			
Plagiogramma vanheurckii			
Rhizosolenia bergonii			
Rhizosolenia hebetata semispina			
Rhizosolenia imbricata			
Thalassionema elegans			
Thalassionema oestruppii			

TABLE 7. Phytoplankton observed at only open-sea stations east of the Galápagos Islands.

Diatoms	Pyrrhophyceans	Coccolithophorids	Silicoflagellates
Bacteriastrum delicatulum	Amphisolenia globifera	Acanthoica acanthifera	Dictyocha deflandrei
Chaetoceros horridum	Ceratium breve	Acanthoica quattrospina	Distephanus sp.
Chaetoceros pseudocurvisetus	Ceratium fusus	Anoplosolenia brasiliensis	
Coscinodiscus nitidus	Ceratium pentagonium	Anthosphaera robusta	
Guinardia flaccida	Oxytoxum caudatum	Discolithus antillarum	
Pseudoeunotia doliolus		Gephyrocapsa caribbeanica	
Rhizosolenia robusta		Ophiaster hydroideus	
Rhizosolenia setigera		Syracosphaera pulchra	
Stephanopyxis palmeriana		Umbilicosphaera mirabilis	
Stephanopyxis turris			
Thalassiothrix curata			

TABLE 8. Phytoplankton observed at both open-sea stations and inter-island stations.

Diatoms	Pyrrhophyceans	Coccolithophorids	Silicoflagellates
Chaetoceros danicus	Ceratium furca	Cyclococcolithus leptoporus	Dictyocha fibula
Chaetoceros decipiens	Ceratium tripos	Emiliania huxleyi	
Chaetoceros didymus	Evuviaella sp.	Gephyrocapsa oceanica	
Chaetoceros peruvianus	Gymnodinium sp.	Syracosphaera tuberculata	
Chaetoceros sp.	Oxytoxum scolopax	Umbellosphaera irregularis	
Coscinodiscus excentricus	Peridinium sp.		
Navicula sp.	Phalacroma mucronatum		
Nitzschia sp.	Podolampas palmipes		
Nitzschia longissima	Prorocentrum sp.		
Nitzschia pacifica			
Nitzschia pungens atlantica			
Planktoniella sol			
Pleurosigma sp.			
Rhizosolenia alata			
Rhizosolenia calcar-avis			
Rhizosolenia stolterfothii			
Rhizosolenia styliformis			
Thalassiothrix frauenfeldii			
Thalassiothrix mediterranea			
Thalassionema delicatula			
Thalassionema nitzschioides			
Tropidoneis sp.			

cinodiscus, *Nitzschia*, *Rhizosolenia*, *Thalassiothrix*, and *Thalassionema*. There were no diatoms found exclusively at the most western collection site, station 112. However, the six diatoms at this station were also found between Ecuador and the Galápagos and within the island waterways. These diatoms were *C. excentricus*, *N. pacifica*, *P. sol*, *R. alata*, *T. delicatula*, and *Tropidoneis* sp. Eleven diatom species were found limited to the open-water stations east of the Galápagos. None of these was found in large numbers.

There were small numbers of pyrrhophyceans in the open-water stations east and west of the Galápagos Islands. Generally they were most common in the samples taken between 10 and 30 m. Of the 31 pyrrhophyceans identified, five species were observed only at the open-sea stations east of the islands and 19 were limited to the inter-island stations. Another nine species were common to both of these areas. *Ceratium massiliense* and *Phalacroma* sp. were found only in the most northern stations (19 and 20) between Pinta and Marchena. Semina (1962) mentions *C. massiliense* as one of the common species along the 174° W meridian in the central Pacific waters, yet it was not noted by Desrosieres (1969). In contrast, the species *Ceratium declinatum*, *C. paradoxides*, *C. trichoceros*, *Danasphaera indica* were found mainly in waters that flowed along the southern margin of the islands. Species limited in appearance to the protected bays were *Amphisolenia* sp., *Dinophysis acuminata*, and *Peridinium globulus*. Only in Elizabeth Bay did any of these species reach large concentrations (*P. globulus*: 5220 cells/l), and in Tagus Cove, where 11 pyrrhophycean species were observed in the sample. The silicoflagellates occurred in 15 of 23 surface samples within the island complex, and at station 112. They were present but rare in the four open-water stations east of the Galápagos. *Dictyocha fibula* was common in the island waters, and was the only silicoflagellate that occurred at both open-water stations and among the islands. *D. deflandrei* and *Distephanus* sp. were observed only at the open-water stations. *Distephanus speculum*, *D. speculum octonarius*, *Mesocena* sp., and *M. polymorpha biseptenaria* were not found beyond the inter-island stations.

Although total counts were not made for the coccolithophorids, relative abundance is noted for open-water and inter-island stations in Table 9. A total of 16 species were identified with *Emiliania huxleyi* ubiquitous and most abundant. This species occurred in cold- and warm-water forms at all but one station. There were no warm-water forms at station 91. The coccolithophorids observed at these stations were at temperatures that correspond closely to the ranges given by McIntyre et al. (in press). However, the cold-water form of *Emiliania huxleyi*, they describe as characteristic for sub-polar waters, remained dominant northward in the Peru Current System, but in reduced percentages in most of the equatorial stations. The cold-water form of *Emiliania huxleyi* was found exclusively at station 91, with a ratio to the warm-water form of 9:1 at station 95, and averaging 5:1 at stations north of the oceanic front and among the islands. Within these waters occurred coccolithophorids with wide temperature tolerances (*Emiliania huxleyi*, *Cyclococcolithus leptoporus*, and *Gephyrocapsa oceanica*), mixed with tropical (*Umbellosphaera irregularis*), the more sub-tropical (*Discosphaera tubifera*) and the sub-polar (*E. huxleyi*—cold-water form) species. It should also be noted that the cold-water form of *Emiliania huxleyi* was still dominant at station 112, located 225 km west of the Galápagos, where the surface waters were 21.86°C. The persistence of these phytoplankters more characteristic to the colder waters into these equatorial areas is significant in their role as indicator species, and possibly reflects wider temperature tolerances to their life processes.

Fifteen of the 16 coccolithophorids were observed at the open water stations, nine species in inter-island channels, with eight common to both areas. The species most frequently noted were *Emiliania huxleyi*, *Cyclococcolithus leptoporus*, and *Gephyrocapsa oceanica*. All other coccolithophorids were in low numbers. These three correspond to dominants mentioned by Hasle (1959, 1960a) in equatorial Pacific collections made west of the Galápagos. Hasle also indicated *C. fragilis* as abundant, but I did not observe this species.

The phytoplankton described above represent a mixture of

TABLE 9. Occurrence of coccolithophorids at open-water and inter-island (1–23) stations. The more abundant species for the stations are indicated, in order of abundance by A, B, and C. X indicates presence. *Emiliania huxleyi* is listed separately for the cold-water and warm-water form.

	91	95	137	141	112	1–23
Acanthoica acanthifera			X	X		
Acanthoica quattrospina			X			
Anoplosolenia brasiliensis		X		X		
Anthosphaera robusta				X		
Cyclococcolithus leptoporus		X	X	X	X	B
Discolithus antillarum				X		
Discolithus tubifera					X	X
Emiliania huxleyi (cold)	A	A	X	A	B	A
Emiliania huxleyi (warm)		B	X	X		
Gephyrocapsa caribbeanica	X			X		
Gephyrocapsa ericsonii						X
Gephyrocapsa oceanica	B	X	A	X	A	C
Ophiaster hydroideus		C	X	X		X
Syracosphaera pulchra				X		
Syracosphaera tuberculata		X				X
Umbellosphaera irregularis					X	
Umbilicosphaera mirabilis				X		

oceanic and neritic species from both tropical, sub-tropical, and equatorial water masses. The Peru Current System dominated by *Chaetoceros* and *Rhizosolenia* species, travels into this equatorial region marked by changing temperature and salinity values. The location of the hydrostations and the Galápagos Islands are approximately along the border separating these major water masses. Large numbers of diatoms predominated at stations close to land and in the protected bays of the island complex. Generally, at stations distant from land or in the more southern or eastern rim of the Galápagos, the diatoms were in lower concentrations, with the phytoflagellates common, but seldom in high numbers. No doubt if the coccolithophorids had been included in the numerical counts of total phytoflagellates, the overall concentrations would be much greater for these samples.

More extensive investigation would be required to offer explanations for several of the distribution patterns presented in the present survey. The study has initiated the problem of distinguishing species distribution that may be considered rational from those which appear to be irrational. The species changes at the four open-water stations between Ecuador and the Galápagos Islands appear to be predominantly rational, especially when matched against temperature and salinity changes. However, within the inter-island complex, there exists larger amounts of plankton near certain islands than elsewhere. The disparity between the distribution of a number of species at one station and the excessive abundance of one or two at an adjoining station constitute features that overshadow the north-south pattern of change within the island complex.

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